

# **Carderock Mine Drop Experiment**

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## **LONG-TERM GOALS**

Mine burial prediction begins with an estimate for the depth of burial resulting from mine impact with the bottom. Recent observations and models suggest that this depth is closely related to the characteristics of the mine flow through the water column. For example, impact angle and velocity are thought to be important parameters. The long term goal of research on this topic is to have the capability to estimate the range of mine fall trajectories and impact conditions that correspond to various mine drop scenarios.

## **OBJECTIVES**

The objective of this effort was to collect data describing the fall of mine-shaped cylinders through the water column. Analysis and interpretation of these data were to be completed under separate efforts.

## **APPROACH**

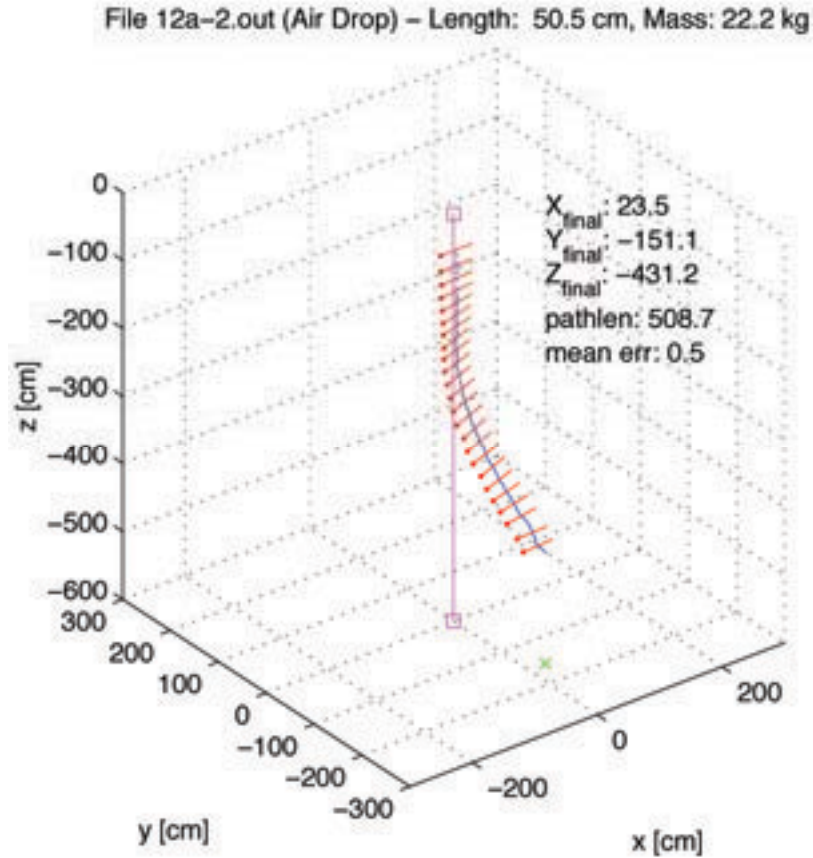
NRL staff designed and fabricated six 1/3-scale cylindrical mine shapes (figure 1) representing the range of foreign threat bottom mines, varying the bulk density, length-to-diameter ratio, location of the center of mass relative to the center of volume, and nose shape (blunt vs. hemispherical). Laboratory tests were conducted at the Explosion Test Pond, Naval Surface Warfare Center, Carderock Division, West Bethesda, Maryland during the week of Sept 10 2001. 1/3-rd scale models representative of prototype mines were used to gather a statistically representative data sample of trajectories. In coordination with NSWC personnel, a digital video recording system was designed for near real time data analysis to yield model trajectory and velocity during free-fall through the water column.

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***Figure 1. Typical one-third scale mine cases.***

A total of 203 drops of the six models were conducted; 75 were released in the air while 128 were released from a totally submerged position. Models were released from orientations of long axis horizontal; long axis vertical, nose down; and intermediate orientations of  $\sim 30^\circ$  to  $45^\circ$  nose down. Of the total drops, more than 190 resulted in digital imagery of sufficient quality for automated data processing producing position and time for two or more points on the model body during fall through the water column. These x, y, z, t data sets were then processed to yield model trajectory, velocity, pitch and azimuth (relative to heading at launch). An example is shown in Figure 2.



*Figure 2. Example of mine fall trajectory and orientation.*

## WORK COMPLETED

Tests were successfully conducted in a professional manner despite the anxiety surrounding world events that week.

## RESULTS

Although detailed interpretation was outside the scope of this effort, some important results were found. Observations of model behavior indicate: (1) when the center of mass (CM) is located near the center of volume (CV), i.e.,  $(CM-CV)/(\text{mine length}) < 0.05$ , then there is a strong tendency for cylinders in free-fall to orient with maximum area presented to the direction of relative flow; (2) for cylinders released in air, trailing air bubbles in the water column dampen boundary layer effects on the cylinder; and (3) with loss of trailing air bubbles, boundary layer effects generate a wide range of motion and lateral excursion for the cylinder.

## **IMPACT/APPLICATIONS**

Since few quality observations of mine fall behavior had been previously made, these measurements are crucial in extending our understanding of the possible range in impact conditions that can be expected for impact burial.

## **TRANSITIONS**

The data collected during this study will be used as ground truth for hydrodynamic models developed at the Naval Postgraduate School and at MIT. In addition, the ranges of behaviors are being parameterized for use in an expert systems approach to impact burial modeling.

## **RELATED PROJECTS**

This effort is closely related to field studies of impact burial being conducted by the Naval Research Laboratory and the Office of Naval Research.